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Dynamic Impact of Carbon Emission Trading on China’s Macro Economy--- Based on CGE Model

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Keywords: Carbon emission trading system, CGE model, Macro economy
Abstract. As the economy develops at a speed in China, the emissions of carbon dioxide also increase on a growing basis, which result in the continuous rise of the seal level and frequent occurring of extreme climates, and become of one the major obstacles impeding the economic development in China. One of the most effective way to reduce the emissions of carbon dioxide is to establish carbon emission trading market and adopt marketization to reduce carbon emissions. In the paper, CGE model of carbon emission trading is built and six-year social accounting matrix (SAM) is compiled. Besides, four emission reduction ratios in different strengths are set up, to conduct model analysis on the influence of carbon emission trading system on China’s GDP and four main bodies of macro economy operation, which are enterprises, residents, governments and foreign people. Based on the model analysis, it has been found that carbon emission trading system has negative impact on China’s GDP, import and export and enterprise investment, and the negative impact present the U-shaped trend. In addition, the carbon emission trading system also plays the negative role on the consumers’ consumption and governments’ taxation. However, the negative impact decreases year by year, suggesting that although the carbon emission trading system has negative impact on China’s macro economy, the negative impact is shrinking in the recent decade. In the current stage, the national carbon emission trading market shall be established gradually, the carbon emission trading system shall be perfected, and the emission amount of carbon dioxide shall be reduced, to build a beautiful homeland of China.

1. Introduction

The Chinese government has made the commitment to the people across the world that in the year of 2020, the carbon dioxide emission amount in per unit of GDP will be decreased by 40%-45% compared to that in 2005, which shows the determination and vision of the Chinese government to control greenhouse gas emissions and build beautiful China. Nevertheless, the national carbon emission trading market has not be established. Among the measures to reduce carbon dioxide emission, currently Chinese government is just to reduce the carbon emission amount by leveraging administrative orders. Even though it keeps on reducing the carbon dioxide emissions, the costs are huge; hence, it could not be adopted in the everlasting and sustainable manner. The measure to reduce greenhouse gas emission by the market can not only achieve the goal to reduce emissions, but also lower the costs. At present, China is in badly need to found the improved and effective national carbon emission trading market.

The model used by economists to analyze carbon dioxide emission trading is CEG model. Ellerman and Wing (2000) utilized carbon emission trading model to analyze the influence of a kind of innovative supplementary means on carbon emission trading against the backdrop of monopsony. Burniaux (2000) adopted general equilibrium model to analyze the influence on Japanese carbon emission trading.

Sun Rui and Kuang Dan (2014) built CGE model concerning China’s carbon emission trading covering the module of carbon emission trading and utilized 2007 social accounting matrix to analyze the influence of carbon trading mechanisms on China’ macro economy under different carbon emission targets. Based on their research, they proposed that the higher the carbon emission trading price is, the fewer the carbon emissions will be and the larger the negative impact on GDP will be. As

for that, Shi Jiarui (2015) conducted more detailed studies, to research the influence of carbon emission trading mechanisms on China's economy and industries under different emission ratios by building four modules of carbon emission trading CGE model. As far as Shi Jiarui is concerned, the higher the emission ratio is, the negative impact on economy will be and the expanding extend of the negative impact will be very fast. In the meanwhile, he presented the idea that carbon emission trading mechanisms have relatively large influence on the industries with high carbon intensity and small influence on the industries with small carbon intensity.

Above all, in the view of domestic and foreign scholars, the influence of carbon emission trading on economy is mainly concentrated on economic growth and static analysis on industry structure. Only a limited number of scholars conduct the research on the mechanism' dynamic influence on economic growth, and there is no study on the mechanism's dynamic influence on enterprises, residents, governments and foreign people. In the paper, on the basis of drawing the experience summarized by the previous scholars and making up the drawbacks in the studies made by the previous scholars, the author mainly studies the dynamic influence of carbon emission trading system on economy. Firstly, it is about the dynamic influence on GDP. Secondly, it is about the dynamic influence on the four main economic operation bodies, i.e. enterprises, residents, governments and foreign people.

The method adopted in the paper is carbon emission trading CGE model, which is to add the module of carbon emission trading into CGE model and adopt the model to analyze the influence on China's economy.

2. Influencing Mechanism

2.1 Interaction among Economic Agents

During the operation of macro economy, the four main bodies, i.e. Enterprises, consumers, governments and foreign people interact with each other, jointly form the macro economy operating mechanism.

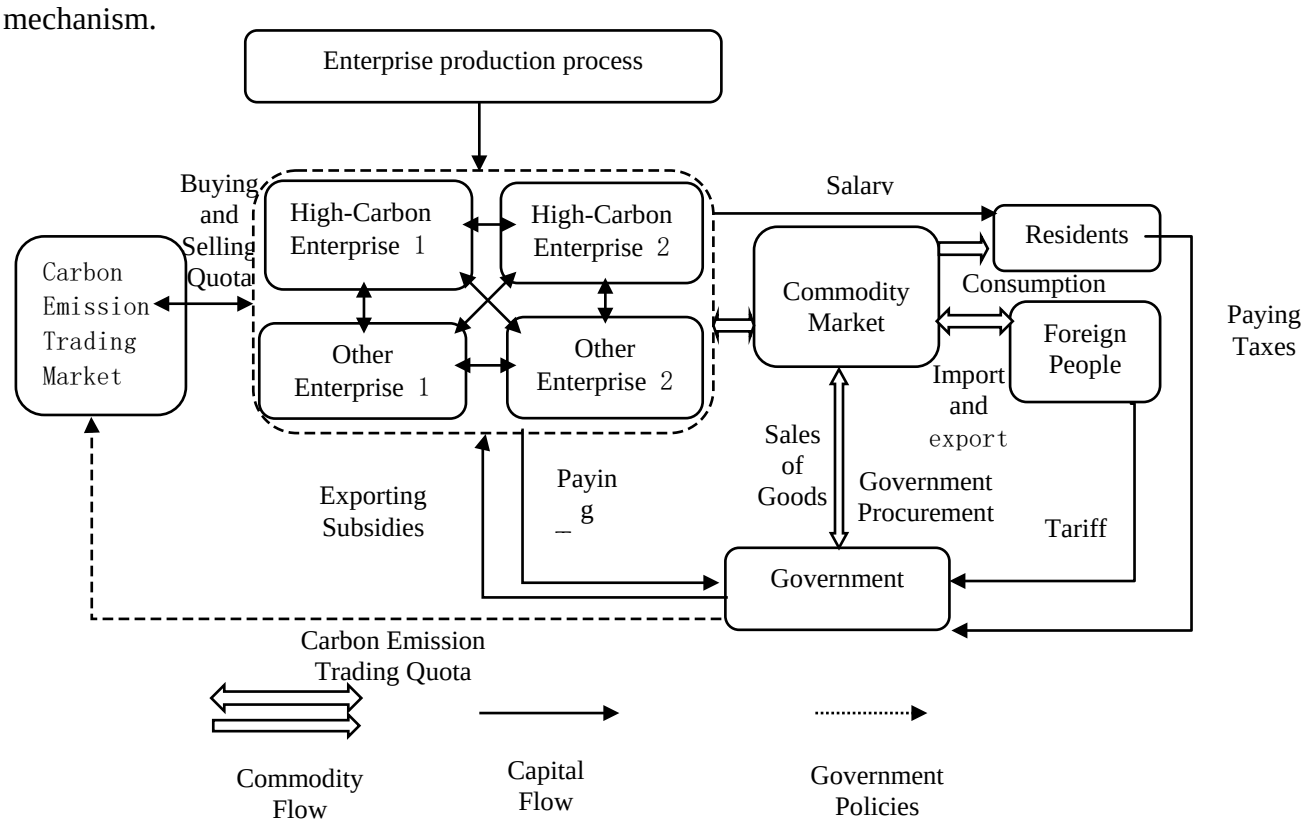

Figure 2.1 Interaction among Economic Agents

In reality, the influencing routes of carbon emission trading market on China's economic agents are extremely complicated; hence, the author just adopts Figure 3.2 to briefly illustrate the influence

of the factors in carbon emission trading market on the various economic agents in China. From the carbon emission trading market, the enterprises can attain initial quota and make free transactions in the market. The behavior of the enterprise influences the producing costs of the enterprises, thus changing the enterprises' decision-making and being delivered in the complicated relations among enterprises, consumers, governments and foreign people, which finally influences the macro economy in China.

2.2 Macro: Exogenous Shock

While discussing the influence of carbon emission trading market on China's economy, the carbon emission market is deemed as the exogenous policy shock of macro economy, to evaluate the influence on China's economy.

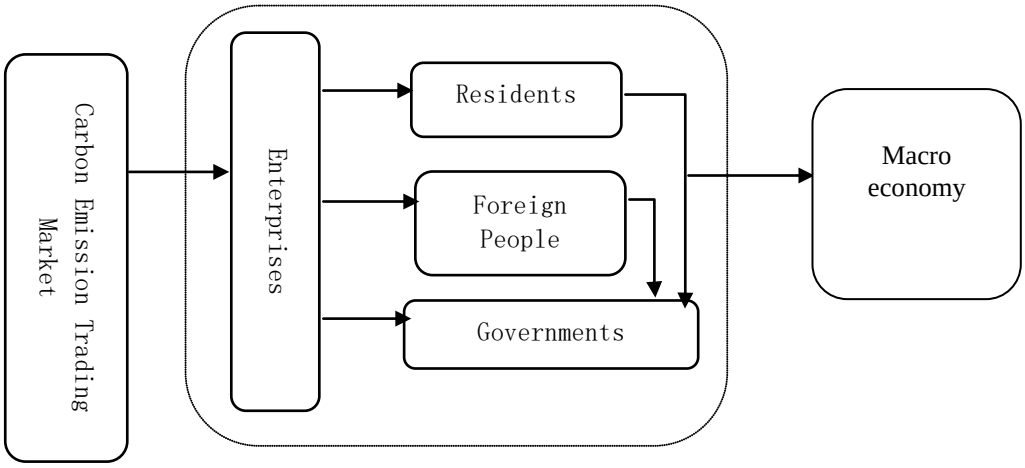

Figure 2.2 Carbon Emission Trading Market's Shock on Macro Economy

From Figure 2.2, it can be seen that the influence of carbon emission trading market on macro economy is deemed as the shock of exogenous shock variable on macro economy. The carbon emission trading market is a exogenous policy variable and is set in an exogenous manner. By varying the key indicators like carbon emission trading market quota and so on, it is made to act on the four economic agents, i.e. enterprises, residents, foreign people and governments, thus influencing the entire macro economy.

3. Model

The carbon emission trading CGE model built in the paper covers one country, two production sectors, three products, four economic agents and five modules. Among the two production sectors, one is to produce the export products and the other is to produce domestic sales products. The division of labor between the two sectors is quite clear. The three products refer to domestic sales products, export products and import products respectively. The four economic agents refer to residents, enterprises, governments and foreign areas respectively. The five modules are production module, nominal production module, price module, carbon emission trading module and equalization module.

3.1 Production Module

The production module is mainly used to describe the supply and demanding situations of foreign and domestic products. The specific expression forms cover the following five equations,

$$\bar{X} = A_t[\delta_t * E^{\rho} + (1-\delta_t) * D_s^{\rho}]^{\frac{1}{\rho}}$$

The functional form is constant elasity of transformation (CET). The function is used to describe the optimal allocation combination of domestically produced products between domestic consumption and export, among which, $\bar{X}$ is gross output and is set in the exogenous manner, suggesting that all the production elements including invested capitals and labor shall be made full use of. δ_t is elasticity of substitution, a exogenous variable. A_t is efficiency parameter and δ_t is share

parameter. By model calibration, the specific values of the two parameters can be calculated in an estimated manner. See Chapter Five for the specific calculation method. E represents exported products and D_s represents supply of domestic products.

$$Q^s = A_q[\delta_q * M^\rho + (1-\delta_q)D_d^\rho]^{\frac{1}{\rho}}$$

The function form is constant elasity of substitution (CES), used to describe the incomplete substitutional relation between domestically consumed products produced in China and the imported products (that is, Armington assumption). Q^s represents the supply of composite commodities. A_q is efficiency parameter and δ_q is share parameters. M represents imported products and D_d represents domestic product demand. σ is elasity of substitution and its specific value is $\sigma = 1/(1-\rho)$. ρ is CES indicator and is set in the exogenous manner. In the carbon emission trading CGE model, the function is deemed as utility function, which is mainly due to that the domestic maximal supply quantity is the maximal consumption quantity of consumers' utility.

$$Q^D = C + I + \bar{G}$$

The quotation suggests that under the condition of international balance of payment, total domestic demand includes consumption demand, investment demand and government demand, among which, government demand is set in the exogenous manner.

$$\frac{E}{D_s} = \left(\frac{(1-\delta_t) * P^e}{\delta_t * P^d}\right)^\Omega$$

Among them, E represents exported products, D_s represents domestic supply of goods, δ_t is share parameters, P^e and P^d represent domestic price of exported products and domestic price of domestic products, and Ω is the elasity of transfer and is set in the exogenous manner; besides, $\Omega = 1/(\rho - 1)$. The equation mainly suggests that the proportion between domestic consumption products produced domestically and the exported products produced domestically is the function between their relative prices. It is the first order condition of CET function.

$$\frac{M}{D_d} = \left(\frac{\delta_q * P^d}{(1-\delta_q) * P^m}\right)^\sigma$$

Among them, M represents imported products, D_d represents supply of domestic products, δ_q is share parameter, P^d and P^m represent the domestic price of domestically produced products and domestic price of imported products, and σ is the elasity of substitution and is set in the exogenous manner. The equation suggests that the proportion between the products imported from foreign areas and the domestic selling products produced domestically is the function between their relatively prices. It is the first order condition of CES function.

3.2 Nominal Production Module

The nominal production module makes the detailed description of the relation among national income, tax revenue, savings and consumption measured in currency. The specific contents cover the following four equations,

$$T = t^m * R * pw^m * M + t^s * P^q * Q^D + t^y * Y + t^e * P^e * E$$

Among them, T represents total tax revenues; t^m, R, pw^m and M represent tariff rate, exchange rate, world price of imported products and imported products. $t^m * R * pw^m * M$ is the import tariff. t^s, P^q and Q^D respectively represent indirect tariff rate, composite products' price and composite

products' demand. $t^s * P^q * Q^D$ represents indirect tariff. t^y and Y respectively represent direct tariff and total income. $t^y * Y$ represents direct tariff. t^e, P^e and E respectively represent export tax rate, domestic price of export products and export products. $t^e * P^e * E$ represents export tariff. The equation suggests that the total tax revenue of Chinese government includes import tariffs, export tariffs, direct tariffs and indirect tariffs.

$$\mathrm{Y} = P^x * X + tr * P^q + re * R$$

Among them, Y represents total income. P^x and X respectively represent total output price and total output. $P^x * X$ represents total nominal output. tr and P^q respectively represent government transfer payment and composite products' price. $tr * P^q$ represents government transfer payment. re and R respectively present foreign private remittance and exchange rate. $re * R$ represents foreign private remittance amount. The equation suggests that China's GNI is the sum of nominal total output, transfer payment and foreign private remittance.

$$\mathrm{S} = \bar{s} * Y + R * \bar{B} + S^g$$

Among them, $\bar{s}$ is average saving rate, Y is national income, and $\bar{s} * Y$ represents domestic average saving deposits. R is exchange rate, $\bar{B}$ is international balance of payment, and $R * \bar{B}$ represents current accounts. S^g represents government savings. The equation suggests that the total savings are the sum of domestic private savings, net amount of current accounts and government savings.

$$\mathrm{C} * \mathrm{P}^t = (1 - \bar{s} - t^y) * Y$$

Among them, C is household consumption, P^t is composite products' price, and $\mathrm{C} * \mathrm{P}^t$ represents net amount of household consumption. $\bar{s}$, t^y and Y respectively represent average saving rate, direct tax rate and GNI. The equation suggests that the household consumption is the balance that GNI subtracts savings and direct taxes.

3.3 Price Module

The price module describes the price relation among economic variables, including imported products' domestic price, exported products' domestic price, selling price of agreeable products, total output price, composite products' price and exchange rate. The specific contents cover the following six equations.

$$P^m = (1 + t^m) * R * pw^m$$

Among them, P^m is the imported products' domestic price, t^m is the tariff rate, R is the exchange rate, and pw^m is the imported products' world price. The equation suggests that the imported products' domestic price is the sum of the imported products' international price and the tariff after adjustment.

$$P^e = (1 + t^e) * R * pw^e$$

Among them, P^e is the exported products' domestic price, t^e is the export tax rate, R is the exchange rate and pw^e is the imported products' world price. The equation suggests that the exported products' domestic price is the sum of the exported products' international price and the export tax rate after adjustment.

$$P^t = (1 + t^s) * P^q$$

Among them, P^t is the composite products' sales price, t^s is the indirect tax rate, and P^q is the price of agreeable products. The equation suggests that the sales price of products in international market is the sum of the composite products' price in domestic market and the sales tax rate.

$$P^x = (P^e * E + P^d * D_s)/\bar{X}$$

Among them, P^x is the total output price, P^e and E respectively represent exported products' domestic price and exported products, P^d和D_s respectively represent domestic products' domestic price and supply of domestic products, and $\bar{X}$is the total output. The equation suggests that the domestic total output price is the ratio between the total price of domestically produced products and total output quantity.

$$P^q = (P^m * M + P^d * D_d)/Q^s$$

Among them, P^m is the imported products' domestic price, M is the imported products, P^d is the domestic products' domestic price, D_d is the demand for domestic products, and Q^s is the demand for composite products. The equation suggests that the domestic total supply price is the ratio between total price of imported and domestically produced products and the demand quantity for them.

$$\mathrm{R} = 1$$

The exchange rate is taken as the basic price and it is identically equal to one.

3.4 Carbon Emission Trading Module

The goal for carbon emission trading system is to reduce the emission of carbon dioxide, thus realizing the target to reduce the emissions of greenhouse gases. In the carbon emission trading system, the general quota for carbon emissions is set at first, that is, the carbon quota. Due to that the carbon supply is limited, carbon has become the scarce resource. The enterprises with high carbon emissions issue requirements on the carbon emissions. During market clearing, the demand of carbon emissions is equal to its supply, and the price of carbon emissions reaches the price of market clearing. With the carbon emission tradings system, carbon has become a production factor, directly affecting the production costs of other industries, especially the industries with high carbon emission, thus affecting the entire national economic system through the market operation linkage mechanism including supply-demand relationship and industry association and so on.

In the respect of carbon emission reduction, China carries out carbon intensity reduction, that is, to reduce the carbon emission quantity per unit of GDP. In the module setting, the carbon intensity index is adopted to measure the carbon emissions.

In the supply of carbon emission trading market, the government sets the carbon emission targets based on the previous carbon emission quantity in industries and international commitments, to set the total carbon emission quantity. The specific details are listed below,

$$\mathrm{TC} = (1 - \gamma)\ TOTC_0$$

Among them, TC is the total carbon intensity emission quota, γ is the introduced exogenous parameter signifying the intensity emission reduction ratio, which is mainly to control the carbon emission transaction quantity, thus realizing the target of carbon emission reduction, and $TOTC_0$ is the carbon intensity emission quantity in the base period.

In the current stage, the free quota distribution is carried out in China, and there is no carbon emission quota auction mechanism; hence, the enterprises do not need to pay for the costs while obtaining carbon emission quota. In China, the relevant punishment mechanism has not been introduced; hence, there is no financial punishment towards the emissions exceeding the limits. Therefore, the carbon emission costs in China are mainly the costs to purchase the carbon emission right. The specific details are listed below,

$$\mathrm{P}^d = P_0^d + \gamma * TOTC_0$$

Among them, P_0^d is the domestically produced products' price in the basic period, P^d is the domestic products' production price in the current stage, γ is the carbon intensity emission reduction rate and also the most import carbon intensity emission reduction ratio, and $TOTC_0$ is the carbon intensity emission reduction quantity in the basic period. The equation suggests the influence of carbon emission reduction on the production costs of domestic enterprises.

3.5 Equalization Module

The carbon emission trading equalization mainly covers the equalization in the following five aspects: the equalization of domestic products' demand and supply, the equalization of domestic composite products' demand and supply, international payment equalization and the equalization of public income and expenditure.

$$D_d - D_s = 0$$

Among them, D_d and D_s respectively represent the domestic products' demand and supply. The equation suggests the equalization of domestic products' supply and demand.

$$Q^D - Q^S = 0$$

Among them, Q^D and Q^S respectively represent the composite products' demand and supply. The equation suggests that the balance between the supply and demand of agreeable products in the domestic market.

$$pw^m * M - pw^e * E - ft - re = \bar{B}$$

Among them, pw^m and M represent the market price of imported products, $pw^m * M$ represents the import of products; pw^e and E respectively represent the price and export of exported products, ft is the foreign transfer payment to the domestic government, re is foreign private remittance, and $\bar{B}$ is international balance of payment. The equation suggests international balance of payment.

$$P^t * I - S = 0$$

Among them, P^t is the composite products' sales price, I is actual investment and S is total savings. The equation suggests the balance between savings and investment.

$$T - P^q * \bar{G} - tr * P^q + ft * R - S^g = 0$$

Among them, T is total taxes, P^q and $\bar{G}$ respectively represent composite products' price and government purchases, $P^q * \bar{G}$ is the costs paid for government purchases, tr and P^q respectively represent government transfer payment and composite products' price, $tr * P^q$ is the costs for government transfer payment, ft and R respectively represent foreign transfer payment to government and exchange rate, $ft * R$ is the domestic price of domestic transfer payment to domestic governments, and S^g is government savings. The equation suggests governmental income and expenditure.

4. Data

4.1 Data Source

The Social Accounting Matrix is compiled according to the input-output table. According to the input-output tables of 2000, 2002, 2007, 2010 and 2012, the social accounting matrix of the corresponding year have been made, as the model parameter calibration data and data standards.

4.2 Calibration of Parameters

Calibration of parameters is also called parameter calibration. It is to endow all prices and other variables with an initial value respectively as the benchmark data, and to evaluate parameters on this basis.

Among the CES production functions, import substitution elasity is set in the exogenous manner. The research of Bao Qin (2013) is adopted. What needs to be calibrated are mainly the substitution index, share parameter and efficiency parameter. The specific contents are listed below,

Firstly, the substitution ρ_q is mainly related to substitution elasity σ_q. The specific contents are listed below,

$$\rho_q = \frac{1}{\sigma_q} - 1$$

Secondly, the calibration of share parameter δ_q needs the parameters and data in social accounting matrix. The specific contents are listed below,

$$\delta_q = \frac{\frac{P_m}{P_d}\left(\frac{M}{D_d}\right)^{(1+\rho_q)}}{1+\frac{P_m}{P_d}\left(\frac{M}{D_d}\right)^{(1+\rho_q)}}$$

δ_q is share parameter, ρ_q is CES index, P_m and P_d respectively represent the imported products' domestic price and domestic products' domestic price; and M and D_d respectively represent the demand for imported products and domestic products in the basic period.

Thirdly, the calibration of efficiency parameter A_q is also based on the basic data in the social accounting matrix. The specific contents are listed below,

$$A_q = \frac{Q_s}{\left(\delta_q * M^{-\rho_q} + (1-\delta_q) * D^{-\rho_q}\right)^{-\frac{1}{\rho_q}}}$$

A_q is efficiency parameter, δ_q is share parameter, ρ_q is CES index, Q_s is the demand for composite products in the basic period, and M and D respectively represent for the demand for imported products and domestic products in the basic period.

In CET production functions, the export transfer elasity σ_t is set in the exogenous manner. The research of Bao Qin (2013) is adopted. What needs to be calibrated are are mainly the substitution index ρ_t, share parameterδ_t and efficiency parameter A_t. The specific contents are listed below,

Firstly, the substitution index ρ_t is mainly related to the transfer elasity σ_t. The specific contents are listed below,

$$\rho_t = \frac{1}{\sigma_t} + 1$$

Secondly, the calibration of share parameter δ_t is both related to the substitution parameter and the basic data.

$$\delta_t = \frac{1}{1+\left(\frac{P_d}{P_e}\right)\left(\frac{E}{D_s}\right)^{\rho_t - 1}}$$

δ_t and ρ_t are respectively share parameter and substitution parameter, P_d and P_e are respectively the domestic products' domestic price and exported products' domestic price in the basic period, and E and D_s are respectively the supply of exported products and domestic products in the basic period.

Thirdly, the calibration of efficiency parameter A_t is also the basic data in the social accounting matrix. The specific contents are listed below,

$$A_t = \frac{X}{\left(\delta_t * E^{\rho_t} + (1-\delta_t) * D_s^{\rho_t}\right)^{\frac{1}{\rho_t}}}$$

A_t, δ_t and ρ_t are respectively the efficiency parameter, share parameter and substitution parameter, X is the total output in the basic period, E and D_s are respectively the supply of exported products and domestic products in the basic period.

5. The Influence on Economy

The influence of carbon emission trading system on economy is quite complicated. In the paper, the author analyzes the influence of carbon emission trading system on China's economy in the angle

of macro economy. In according to the commitments made by the Chinese government to the international carbon emissions and considering China's capability to fulfill the target of carbon emission reduction, four carbon intensity emission reduction ratios are determined, to analyze the influence of carbon emission trading system on China's economy by the carbon emission trading CGE model.

5.1 Stimulation of Carbon Emission Trading System

China's carbon emission reduction target made by the Chinese government to the world is to reduce the carbon dioxide emissions by 40% to 45% in 2020 compared to that in 2005. By making the calculation of the annual average GDP growth rate of 7% in China, in order to realize the carbon intensity emission reduction of 45% in the year of 2010, the annual carbon intensity emission reduction ratio shall be 2.977%. In order to realize the carbon emission reduction of 45%, the annual emission ratio shall be 3.818%. Based on the commitments made by the Chinese government and the economic development speed in the future, four carbon emission reduction ratios are set. The annual carbon intensity emission ratios are respectively 1%, 3%, 4% and 5%, so as to analyze the possible influence of carbon emission trading system on China's economy.

5.2 Influence on Economy

The influence of carbon emission trading system on economy is multiple. In the paper, the four main subjects of the economic whole and the economic operation are the subjects of analysis, to comprehensively analyze the influence of carbon emission trading system on China's economy. The specific analysis is listed below,

5.2.1 Influence on GDP, Enterprise Investment, Import & Export

The specific influence of carbon emission trading on China's GDP, enterprise investment and import & export in in the "U" shape. The specific contents are listed in the following graphs,

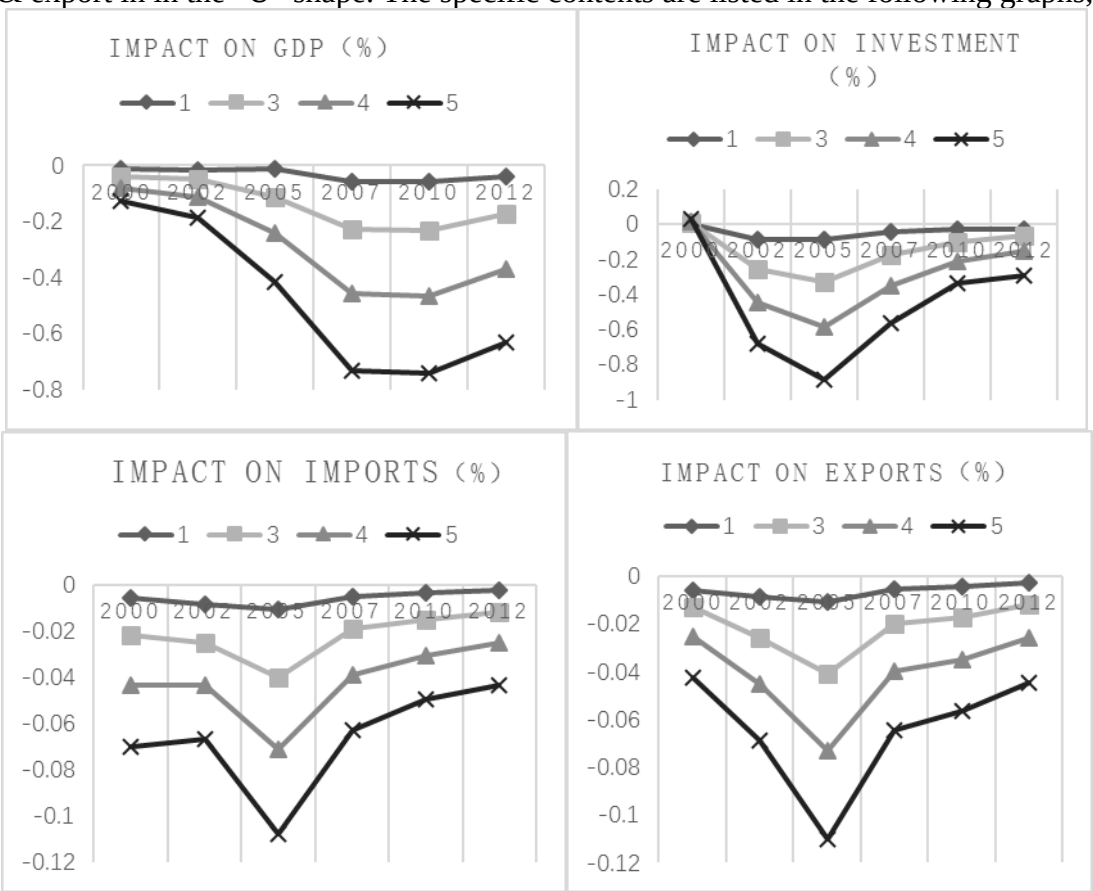

Figure5.1 Influence of GDP, Investment, Import and Export

From Figure 5.1, it can be seen that the carbon emission trading generate negative impact on GDP, investment, import and export.

In time dimension, the influence of carbon emission trading system on GDP, investment, import and export presents the U-shaped structure. The turning point of the structure from being large to

being small is during the period from 2005 to 2007. The main reason generating the U-shaped structure is that since the period from 2005 to 2007, the outlook of scientific development was presented in China, setting store by the adjustment of economic growth structure and vigorously developing the high-tech industries and promoting the upgrade of enterprises' technologies. A series of measures have been adopted to improve the capability of China's economy to resist the negative impact of carbon emission trading system, thus gradually reducing the negative impact of carbon emission trading system on China's economy.

Vertically, as the annual carbon emission strength gradually rises from 1% to 5%, the negative impact of carbon emission trading system on GDP, import and export and enterprise investment becomes larger and larger; besides, the per unit negative impact also becomes stronger and stronger, suggesting that it is not appropriate to set too high carbon emission reduction target in China, because it might heavily harm China's economy.

5.2.2 Influence on Household Consumption and Government Taxes

The influence of carbon emission trading on household consumption is mainly delivered to consumption and taxes by influencing the production in enterprises. The specific contents are listed in the following graphs,

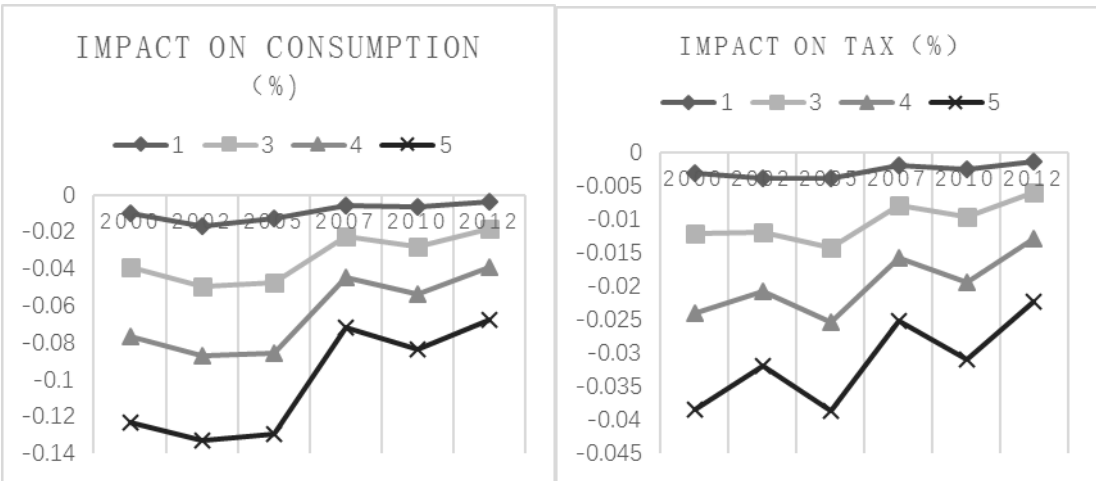

Figure 5.2 Influence on Household Consumption and Government Taxes

From Figure 5.2, it can be seen that the carbon emission trading generates negative impact on consumption and taxes.

In the angle of time direction, the influence of carbon emission trading on consumption and taxes presents rising trend on the whole, suggesting that the influence of carbon emission trading system on consumption and government taxes becomes smaller and smaller, which is conducive to implementing national carbon emission trading system in the current stage.

Vertically, with the increase and decrease of carbon emission intensity, the influence of carbon emission trading on consumption and taxes becomes smaller and smaller, which is rightly contrary to its influence on GDP, import and export and enterprise investment.

6. Conclusion

In the paper, the carbon emission trading CGE model is established, to make the stimulated research on the negative impact of carbon emission trading system on China's GDP, enterprises, residents, governments and foreign people.

The carbon emission trading will generate negative impact on China's GDP, enterprise investment and import; however, the negative impact on them presents the U-shaped structure, and the negative impact on China's consumption by consumers and government taxes presents the rising trend. From the analysis, it can be obtained that to make the analysis in the two angles of negative shock and reaction rate, the influence of carbon emission trading system on China's macro economy decreases year by year.

According to the conclusions in the paper, while promoting the supply-side structural reform and encouraging high-tech industries and third industry development, the national carbon emission trading system shall be gradually implemented, to realize the promised carbon intensity emission reduction target and realize the goal to build beautiful China.

References

[1]Ellerman A D, Wing I S. Supplementarity: An Invitation to Monopsony?[J]. Energy Journal, 2000, volume21(4):29-59.

[2]Burniaux J M. A Multi-Gas Assessment of the Kyoto Protocol[J]. Oecd Economics Department Working Papers, 2000, 401(6753):549-555.

[3] Sun Rui, Kuang Dan and Chang Dongqin. Analysis on Carbon Trading Effects upon Energy-Economic-Environment and Calculation of Reasonable Carbon Price Intervals [J]. China Population Resources and Environment. 2014,07:82-90.

[4] Shi Jiarui, Cai Hailin and Yang Ling et. al. Research on the Impact of Carbon Trading Mechanism on China’ Economic Environment Based on CGE Model [J]. Chinese Journal of Management Science, 2015(S1):801-806.

[5] Bao Q, Tang L, Zhang Z X, et al. Impacts of border carbon adjustments on China's sectoral emissions: Simulations with a dynamic computable general equilibrium model[J]. China Economic Review, 2011, 24(1):77-94.